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Evaluating Teacher's Skills in STEM Education to Increase the Student Engagement

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Abstract. In Latvia, basic education is the stage when teachers seriously consider students' possible career development. Employers, especially in STEM (Science, Technology, Engineering, and Mathematics) related jobs, are raising concerns about the lack of skilled employees. The ability to perform research and decision-making, collaboration and communication skills are highly demanded in the labour market. To ensure students' interest in STEM subjects and STEM-related career paths, teachers must facilitate the development of positive attitudes towards these disciplines. It raises the question of whether educators themselves possess the necessary skills to effectively teach the STEM disciplines according to the cognitive abilities of each student. This study aims to determine how teachers evaluate their own skills for teaching in the STEM field in Latvia and what can be accomplished to improve these skills. To achieve this goal, a survey method was employed, and scientific literature and normative documents were analysed. The survey comprised both open-ended and closed-ended questions; and obtained data was summarized using figures and then analysed drawing conclusions and providing suggestions. 20% of all surveyed teachers are unable to articulate an opinion or propose solutions necessary for the improvement of teachers' skills and knowledge in the STEM field. The findings indicate that there is a necessity for improvement and perfection in teachers' skill sets in relation to the STEM field.

Keywords: STEM; skills; teacher; basic education

Introduction

According to EURES (European Employment Services) (EURES, 2024), in Europe, there are approximately 1 180 087 vacancies (search made using keywords Science, Technology, Engineering, and Mathematics) in the STEM related fields. Therefore, it is important to raise awareness and prepare the specialists for these disciplines. To fulfil this goal, it is especially important to raise the interest in these subjects already on the basic education level at schools and to arouse curiosity in learners, laying the foundation for future employees who choose a career in STEM related disciplines.

Despite the differences in each country's education system, there is one common goal. All school leaders want to employ self-confident and highly educated teachers who are knowledgeable, skilled and capable to change and adapt to the demands of present times and who can inspire and encourage students to take sensible risks, set high aca-demic goals and

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achieve these goals for the sake of better future. Kelly and Knowles (Baharin, Kamarudin & Manaf, 2018) suggest that STEM education requires basic knowledge and a strong understanding of concepts that enable students to comprehend and apply STEM knowledge. Bandura (Bandura, 1997) highlights three most important factors that promote cognitive development: 1) the students' belief in their ability to regulate the learning process by improving their academic knowledge, 2) the teachers' self-efficacy in their ability to motivate and promote the learning process and set the common goals of the educational institution (and the education system as a whole), and 3) a common understanding of the achievable results and methods for achieving high academic performance.

The researchers assert that highly motivated students exhibit significantly greater effort in mastering new tasks, and they employ self-efficacy and elaborative strategies more effectively than their less motivated counterparts (Aidoo, Chebure, Gyampoh, Tsyawo, & Quansah, 2024), therefore it important for teachers to set up learning exercises and tasks in a way that students are able to seek the information and find the answers by themselves and interact with teachers, parents and peers to reach their target.

It raises a question of how confident are the teachers and how they evaluate their own self-efficacy, skills and knowledge in the STEM field. The survey was conducted to gather insights into teachers' perception of their skills and knowledge in the STEM field.

Literature review

Changing times require different approaches, new methods and teaching techniques (Voogt & Roblin, 2010). STEM education provides an excellent opportunity for fostering 21st century skills, such as such as collaboration, communication, creativity, and critical thinking. In the school environment, the teacher is the main facilitator of students' achievement and success, thus, by creating conditions that promote academic achievement and growth, the teacher becomes a role model for the students. Students can use the learning environment created by the teacher as a supportive resource – not only for acquiring the curriculum, but also for gaining emotional support, environment where students are encouraged to explore, question, and construct knowledge collaboratively (Kock et al., 2013). Consequently, the student's socio-emotional state is affected, which in turn affects the student's academic achievements (Engels, Split, Denies, & Verschueren, 2021). Students require not only a teacher who possesses mastery of the subject matter and delivers it effectively but also the one who demonstrates care and exhibits behaviours that foster their interest in learning (Ukobizaba, Ndihokubwayo, & Uworwabayeho, 2020), especially when teaching in STEM related areas. It is important not only for the education in the classroom, but also for the future economy altogether. Teachers must use questioning strategies to challenge students to think using their higher cognitive skills so they will think deeply about the concepts and ideas in order to solve the STEM challenges (Margot & Kettler, 2019). Basic school is crucial time to develop students' interest in STEM education. According to the development of the student's cognitive abilities theories, it is time when students thinking process begins to free itself from attachment to a specific situation or objects and moves to an abstract level showing the ability to put forward abstract hypotheses, test them, and judgments are also perceived as hypotheses that can have various consequences. (Kalvāns, 2018) As research (Owusu, Owusu, Fiorgbor, & Atakora, 2021) shows, students see their teachers as role models and attach high value to their advice and guidance when it comes to career choices.

Making the right career choices is one of the most crucial decisions in a student's life, therefore getting motivated and staying motivated plays a key role for navigating this journey. Employing the career guidance, the students can align their passions and skills and build a

fulfilling career. According to SCCT (Social cognitive career theory) there are two complementary levels of theoretical analysis. They are the cognitive personal variables such as self-efficacy, outcome expectations, personal goals and personal control, and several additional sets of variables – such as physical attributes, environmental features, and particular learning experiences that influence the person's career-related interests and choices (Lent, Brown & Hackett, 2000).

As previously stated, teachers play a fundamental role in influencing students' academic growth therefore two questions become significant. First – What are the characteristics of a good, inspiring teacher, and second – What are the requirements for the teachers for mastering their job and being a proficient teacher? Research shows, that good, inspiring teacher should:

- Make courses interesting
- Stimulate students to interact with each other
- Be well-prepared
- Provide constant feedback
- Be a good role model
- Be approachable
- Be able to keep discipline ect. (Afida, Mustaffa, Basir, & Tahir, 2023)

Teaching has been identified as a highly demanding career where teachers are subjected high levels of work-related stress and burnout (Hakanen, Bakker, & Schaufeli, 2006), and teachers' professional wellbeing is linked to students' performance. Studies divides five main groups of wellbeing: cognitive wellbeing, subjective wellbeing, physical and social wellbeing, and mental wellbeing (Viac & Fraser, 2020). Professional standard of teacher requires ability not only to teach learning material, but planning the learning process, assessing student learning performance and growth, improving professional competence and involvement in the development of the educational institution and the field of education (Pakalniņa & Ročāne, 2024)

In the learning process, the knowledge acquisition, skill development and also the cultivation of positive attitudes are crucial for both – the educators who serve as the role models, and also the students. In the teaching and learning process, it is possible to distinguish two types of skills – soft skills, used to indicate all the competences that are not directly linked to a specific task, and hard skills that indicate the specific capabilities needed to perform a particular task (Cimatti, 2016). Teaching and learning in the field of STEM, require not only fulfilment of individual tasks, but also collaboration and ability to work in a team. Research study (Blömeke, Busse, Kaiser, König & Suhl, 2016) states that no matter which subject is taught, the teacher's competency is closely linked to the quality of classroom performance. Therefore, it is crucial to examine the teachers' self-assessments, specifically how they evaluate their own knowledge and skills in STEM fields. This understanding enables educational policymakers to enhance this area, fostering overall development and supporting career choice opportunities for the graduates.

Methodology

The aim of this study is to determine how the teachers of Latvian schools evaluate their proficiency of teaching in the STEM field and what can be accomplished for improving their skills. To achieve this aim, two research questions were put forward:

1. How do teachers assess their skills and knowledge in the STEM field?
2. What can be done to improve the teaching and learning in STEM based education?

In relation to the research objectives, the following tasks were determined:

- to build a theoretical foundation using analysis of scientific literature and normative documents in order to understand the teachers' role and impact in career related decisions of students;
- to develop a survey for exploring how teachers evaluate their own knowledge and skills in the STEM field, and what improvements can be made.
- to analyse the data acquired from the empirical study with the aim of developing conclusions and proposing recommendations for perfection of STEM education.

The empirical data have been obtained using an online questionnaire consisting of closed-ended and open-ended questions. The survey was sent directly to schools, to school principals, so that the principals can further distribute it to the teachers using the school's internal communication system. Four types of schools were chosen for this research - Primary school (grades 1 to 6), Basic school (grades 7 to 9), Secondary school (grades 10 to 12) and Vocational secondary education schools (grades 10 to 13, includes secondary school curriculum plus special training for the chosen profession) (Ministry of Education and Science of Republic of Latvia, 2020). Survey participants: 243 teachers from all regions of Latvia (Kurzeme Region, Latgale Region, Rīga Region, Vidzeme Region, Zemgale Region (Legal acts of the republic of Latvia, 2025) from all age groups (min=20, max=85) and with various length of service (min=1, max=58 years). The survey participants were asked to self-assess their skills and knowledge in the STEM field using a five-point scale (from 1 to 5), where 1 means basic knowledge, 2-intermediate knowledge, 3-proficient knowledge, 4-advanced knowledge, and 5-expert knowledge, and respond-ents were encouraged to provide recommendations for improving the STEM education process in schools. The data was processed using Microsoft Excel and SPSS software, with the results summarized in figures. To examine the differences between respondent sub-groups, the Mann-Whitney U test was followed by discussion and conclusions.

Results and Discussion

39.5% of teachers who participated in the survey evaluated their knowledge in STEM field as advanced or on the expert level (see Figure 1), mode (the value of a variable which occurs most frequently, (Mo) = 3, median (the middle value in an ordered set of data), (Me) = 3. Even less, only 36.6% of teachers evaluated their skills in STEM field as advanced or in expert level (Mo)=3, (Me)=3, and this is a lower indicator compared to the self-assessment of knowledge. One of the factors influencing the results may be the teachers' self-concept. Self-concept refers to an individual's perception of themselves and encompasses three key dimensions: self-awareness (knowing oneself), self-respect (valuing oneself), and self-assessment (evaluating oneself). It plays a crucial role in shaping behaviour, influencing how individuals act and respond in various situations (Channawar & Jha, 2024)

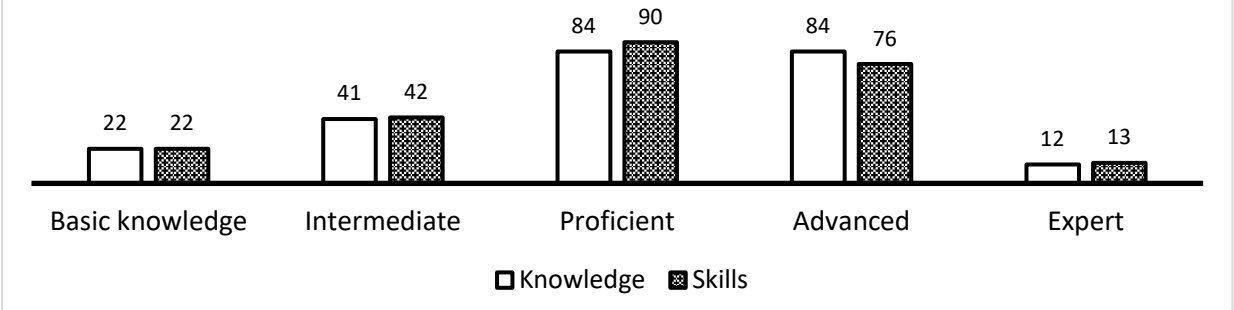

Figure 1 ***Teachers' self-assessment of knowledge and skills in the STEM field (n = 243), (n = the number of re-sponses in the group)***

As previously stated, basic school is crucial time to inrease students interest in STEM education. To better integrate STEM at this education level is important to assess basic school techers' knowlage and skills at STEM education. From all participants, 127 (n = 127) teachers work at basic school level. Their opinion allows to better understand the situation at basic school level in order to acomodate the teachers' needs and provide the necessary support. The comparison was made between regions of Latvia and the capital city Riga.

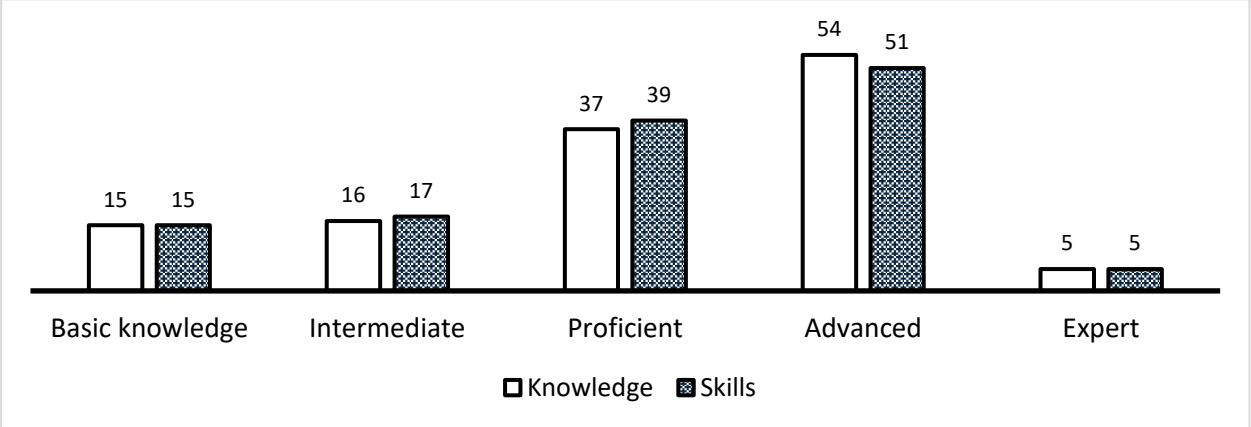

Figure 2 ***Basic shool teachers' self-assessment of knowledge and skills in the STEM field (n = 127)***

Analysing the obtained data, it is seen that the average values of the territorial planning regions in both the "knowledge" and "skills" dimensions fluctuate within a relatively small amplitude, indicating an even distribution of assessments among the regions of Latvia. The average indicators (Mean) range from approximately 3.2 to 3.5, which does not indicate any significant differences between Riga, Kurzeme, Vidzeme and Latgale. However, it is seen that Zemgale ratings are slightly lower: in the "knowledge" dimension they reach 2.86, compared to, for example, Riga 3.50 or Latgale 3.55, while in the "skills" dimension, Zemgale has 2.86, while Riga has 3.25 and Latgale 3.36 Although these differences are not large, they show a slight tendency that Zemgale teachers rate the relevant areas lower than other regions, raising the question of what directly influences such results. Analysing the answers of Zemgale teachers on the open question about what support STEM teachers need, they indicate that *"...support is needed in providing teaching materials and for carrying out practical work", "…the inclusion of real-life examples in the learning process would be beneficial."* Using SPSS software and performing statistical comparison procedures, no statistically significant differences were found between regions.

Although 243 respondents participated in the survey, 348 responses were gathered for the open-ended question "What can be done to improve teaching and learning in STEM-based education?", as many teachers work at multiple educational levels and, therefore, they are qualified to provide insights based on all their levels of expertise. The various suggestions and problem issues were outlined in all four levels of education (see Figure 3). For example, a primary school teacher suggested that *"... although there are many methods available, for the primary school learners it is better to vary the methods during the lessons so that children do not lose the interest. The most effective methods are the ones with a practical focus!"* A basic school teacher commented that there is a need for "different outsourced classes so that the students see what is underneath the theory…".

Secondary school teachers are concerned that "there is a lack of teaching aids. Teachers spend too much time preparing for lessons and developing their own teaching materials". If the previous three educational levels are more academically focused, Vocational secondary

education schools emphasize the technical side of education, saying that "there is a lack of prior knowledge for students". All answers were divided into seven groups (see Figure 3).

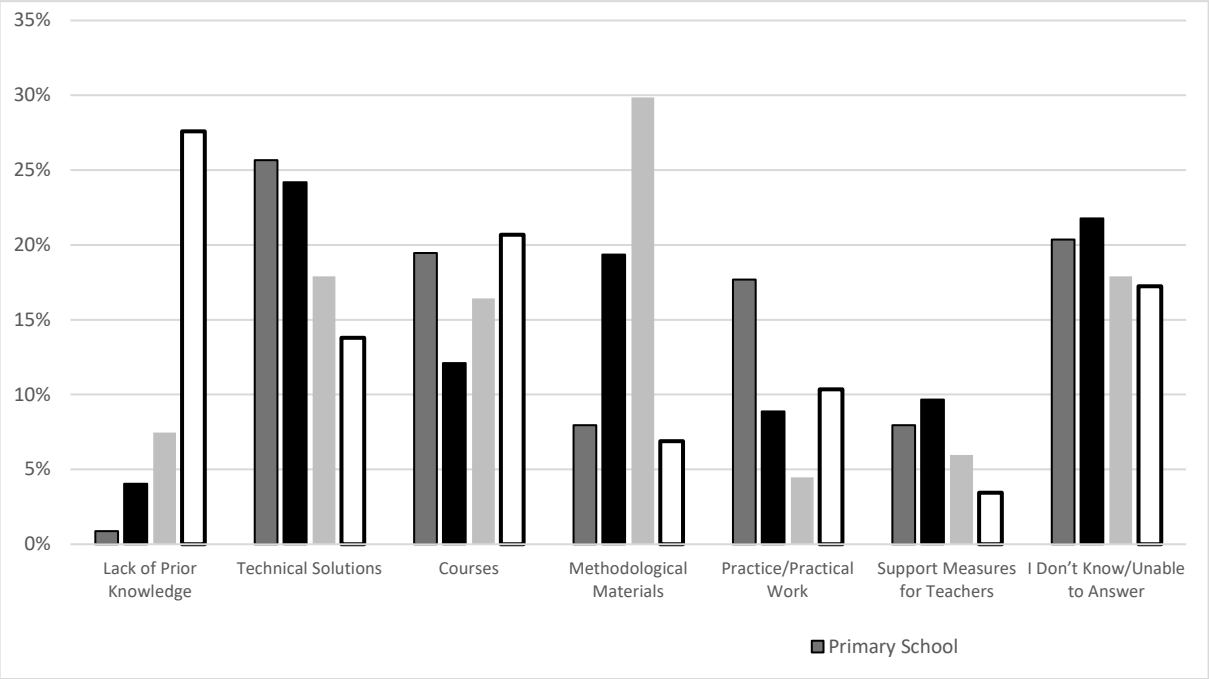

Figure 3 ***Relative frequency of recommendations for improving STEM teaching in schools (n = 243)***

Nearly 20% of teachers from each represented educational level were unable to provide any specific suggestions regarding the necessary improvements in STEM-based education. This raises an important question: what could be the underlying reasons for such a lack of vision? One of the main reasons could be the burnout. The concept of burnout can be broken down into three subsections: emotional exhaustion (EE), personal accomplishment (PA), and depersonalization (DP) (Channawa, & Jha, 2024; Kondo et al., 2024). According to the research performed by Ministry of Education and Science of the Republic of Latvia, 53% of Latvian municipalities lack teachers' assistants, 84% - educational psychologists, 58% - school social pedagogues (The State Audit Office of the Republic of Latvia, 2024). Lack of support places an additional burden on teachers – both for teaching and decision-making. Obtained data proves that 39% of all surveyed teachers work within two educational levels or even more. Without necessary support, it can lead to burnout and make decision-making difficult. For future research, it is important to explore teachers' workload, professional development courses and extracurricular enhancement programs, as well as their impact on teachers' self-efficacy (Djazilan et al., 2022). Further research directions could be related to how teachers collaborate with one another, what support is provided from various methodological committees, and how these committees interact with each other. Further-more, exploring how knowledge transfer and information sharing occur in order to promote a more effective teaching process, particularly in the field of STEM education, would be of significant value.

Conclusions

This empirical study, together with the analysis of scientific literature and regulatory documents, allows to draw the following conclusions:

- Although, based on teacher's self-assessment, on the highest levels (4-advanced, 5-expert) the gap between knowledge and skills is less than 3%, this indicates that there is a need to foster the transfer of knowledge into skills.
- Significant correlations between teacher's age (Min=20, Max=85) and length of service (Min=1, Max=58 years) in terms of teacher's self-assessment of their knowledge and skills were not found.
- To improve STEM teaching in schools, the recommendations include providing accessible practical work kits and high-quality teaching materials such as textbooks and workbooks aligned with curricula, as well as enhancing teachers' foundational knowledge through courses and development of methodological resources. These measures collectively aim to enhance the quality and effectiveness of STEM education, fostering higher learning outcomes.
- Vocational secondary education programmes that include practical experience and direct engagement with STEM have raised concerns about the lack of prior knowledge among students. Therefore, there is a need to place greater emphasis on STEM education quality at the basic education level.
- Lack of support for teachers can lead to burnout, corrupt decisions and ineffectiveness when accomplishing the tasks required by education policy makers, and can reduce self-efficiency of teachers.
- To interest students in choosing a STEM-related profession in the future, a teacher must be competent in the STEM field, able to express and justify their opinion, and actively involved in promoting the quality of education.

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